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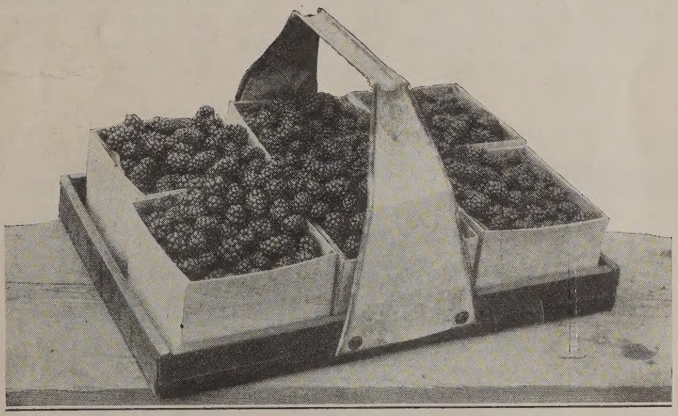
SPRAYING DEWBERRIES FOR ANTHRACNOSE

By W. C. DUTTON



AGRICULTURAL EXPERIMENT STATION
MICHIGAN AGRICULTURAL COLLEGE

HORTICULTURAL SECTION

East Lansing, Michigan

Spraying Dewberries for Anthracnose

BY W. C. DUTTON

The dewberry industry in Michigan is relatively new, when compared with that of apples or peaches. Like most crops when first introduced in a territory, it has been relatively free from insects and fungus diseases but in recent years several pests have assumed commercial importance. Among these, anthracnose is one of the most important.

A serious infestation of anthracnose may cause immediate loss through reducing the crop of the current season by girdling the fruit-bearing pedicels. It may also affect the general vigor of the new shoots by direct cane infection or by injuring the leaves so that many of them do not function properly or even fall off prematurely. It is probable also that the girdling caused by the old lesions on the main bearing canes may more or less directly influence the development and maturing of the fruit.

Fig. 1.—Anthracnose on shoot, petiole and leaf of the dewberry. Photographed August 9, 1924.

Anthracnose is caused by a fungus known as *Plectodiscella veneta.* It lives over winter in gray spots which develop on the canes of the previous seasons growth. In early summer during rainy periods, spores are discharged from these diseased areas and are washed or splashed onto the new shoots which are growing from the crown, and onto the flower and fruit-bearing laterals which grow out from the old canes. The disease

first becomes noticeable in the form of small purplish spots which enlarge and become white in color. If numerous these spots may coalesce forming large irregular areas which may partly or entirely girdle the shoot or fruit bearing pedicel. Only young, tender growth is susceptible to infection. Secondary infection may occur during the summer, so that the new shoots from the crown will be affected for some distance from the parent plant. The disease is also frequently seen on the leaves and petioles (leaf stems). There are also other leaf-spot diseases which attack the dewberry, but it is often difficult to distinguish between the different forms of leaf-spot without a microscopic examination.

SPRAYING TRIALS

Spraying experiments with dewberries began in 1922. Although, little information was available concerning dewberry spraying and the work the first year was preliminary in nature, an attempt was made to obtain definite information on several specific questions. Among these were: (1) Can anthracnose be controlled satisfactorily? (2) If it can be con-

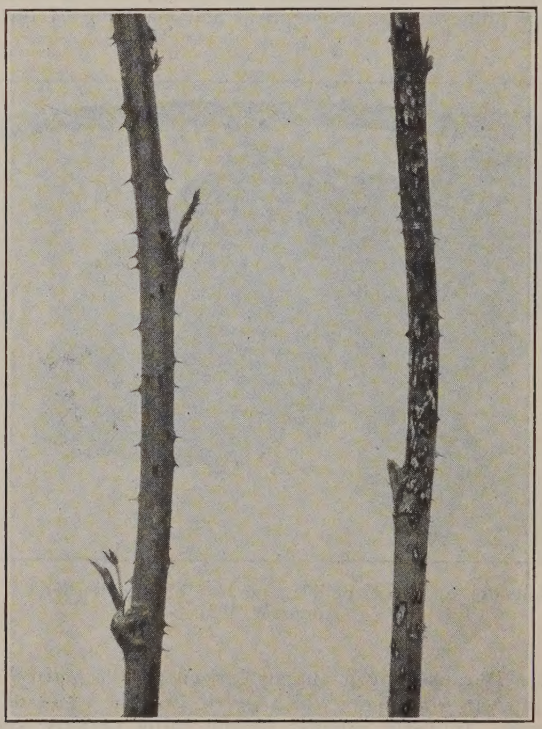


Fig. 2.—Results from spraying for the control of anthracnose. Cane from a sprayed plant at left and from an unsprayed plant at right. The leaves have been removed. Photographed August 9, 1924.

trolled, what schedule of application is necessary? (3) What material and what strength of materials is best for its control? (4) To what extent is the dewberry subject to foliage injury by spraying materials? (5) Will spraying result in higher production of fruit, in other words, "Will spraying pay?" The first experiments included a rather large number of materials or combinations of materials and with a varying number of applications. As the work progressed, certain materials and applications which were not necessary or desirable were eliminated until a satisfactory schedule and combination of materials was worked out in 1924.

The experimental work was all done on the farm of Mr. W. E. Daly, one and one-half miles southwest of Riverside, Berrien county. The planting was of Lucretia, twelve years old in 1922. The soil is of the sandy type typical of that district, but, because of the use of manure and fertilizers, is in a much better than average state of fertility. Thorough cultivation was given each year until the harvest period. The vines were large and usually made a rank growth resulting in many secondary shoots. The canes were tied up to the regular trellis and cut off at a height of 2½ to 3 feet.

Arrangement of the Plots and Materials Used. The plants stood at 3 feet intervals in rows 7 feet apart, with a 10 feet space every sixth row. Since the rows were 31 rods long, each group of six rows contained over half an acre. Certain of these groups were used at plots in the spraying work, one serving for each treatment. The two middle rows of each plot were left untreated as checks. This arrangement of plots was continued through all the work, but some changes were made in the materials. The materials and the applications for which each was used are

Table 1. Materials Used in Dewberry Spraying Experiments.

Plot	Rows	1922	1923	1924
1	1, 2, 5 and 6	Lime-sulphur plus calcium caseinate for all applications.	Lime-sulphur plus calcium caseinate for all applications.	Lime-sulphur plus calcium caseinate for delayed dormant. Lime-sulphur alone for summer application.
	3 and 4	Check, no treatment.	Check.	Check.
2	1, 2, 5 and 6	Lime-sulphur for delayed dormant, bordeaux plus resin fish-oil soap for summer applications.	Lime-sulphur plus calcium caseinate for delayed dormant, bordeaux for summer, applications.	Same as for 1923.
	3 and 4	Check, no treatment.	Check.	Check.
3	1, 2, 5 and 6	Bordeaux for all applications.	Lime-sulphur alone for delayed dormant application. Bordeaux for summer application.	Same as for 1923.
	3 and 4	Check, no treatment	Check.	Check.
4	1, 2, 5 and 6	Bordeaux plus calcium caseinate for all applications.	Bordeaux for all applications.	Same as for 1923.
	3 and 4	Check, no treatment.	Check.	Check.

indicated in Table I. Lead arsenate was added each year in the application just before the blossoms open for the control of the cane-borer.

The calcium caseinate used was a commercial product. The resin fish-oil soap was the semi-liquid form commonly used throughout the grape districts. Wherever lime-sulphur was used it was the standard commercial liquid lime-sulphur. The strength of the bordeaux was varied somewhat for different applications. The strength at which each material was applied is indicated in Table 2.

Table 2. Amounts of Materials Used per 100 Gallons of Diluted Spray.

Material	Application	1922	1923	1924
Lime-sulphur	Delayed dormant Summer	12½ gal. 2 gal.	12½ gal. 2 gal.	5 gal. 2 gal.
Bordeaux	Delayed dormant Summer	8-12-100 6- 8-100	8-12-100 6- 8-100	8-12-100 4- 8-100
Calcium caseinate	Delayed dormant Summer	¾ lb. ¾ lb.	¾ lb. ¾ lb.	1 lb. .....
Resin fish-oil soap	Delayed dormant Summer	4 lbs. 3 lbs.	....	....

Method of Application. All spraying was done with a large power orchard sprayer. The application was made with spray guns in every instance, but the pressure was not always as high as desirable. The work was sometimes done with two men spraying, but usually with only one. The sprayer was driven through the wide spaces and the two outside rows on each plot were sprayed. A pole about ten feet long was suspended on the sprayer so as to extend out over the rows when it was necessary for the man doing the spraying to work beyond the first or second row. In 1922 and 1923 the delayed dormant application was made before the canes were tied to the wires and the spray was directed downward. The delayed dormant application in 1924 was made after the canes were tied up to the trellises. For this application, and all summer applications, the spraying material was applied to both sides of every sprayed row.

Schedule of Applications. The number of applications made in 1922 was rather large. There were two principal reasons for this; first to determine if repeated applications are necessary to prevent the spread of anthracnose on the outer portions of the new shoots, and second, to control Septoria leaf-spot. The plan of working out a control for leaf-spot was given up as it was found to be relatively unimportant and as more was learned about the control of anthracnose the number of applications was reduced. The schedule and dates of applications for the three years are shown in Table 3. The period during which the delayed dormant application can be made is usually rather short as the canes are not uncovered until about the time the buds start into growth. In this work the delayed dormant application was usually made when the buds had expanded to about one-half inch in length. In 1924 they were more advanced than that and, to avoid possible injury to the buds, the strength of the lime-sulphur was reduced.

Amounts of Material Used. The amount of each material used at each application varied so little that the records for 1924 only are given here. For the delayed dormant application, lime-sulphur and calcium caseinate were used at the rate of 283 gallons of diluted material per acre and for the summer applications, bordeaux and lead arsenate were used at the rate of 340 gallons per acre.

The time required to do the spraying will vary widely under different conditions, depending on the equipment, the method of application and the size of the plants. It is not possible to obtain accurate labor costs in connection with experimental spraying but a fairly close estimate can be made of the time required. Four acres of large plants may be sprayed in a day under favorable operating conditions. With lime-sulphur costing 16 cents per gallon; calcium caseinate, 20 cents per pound; copper sulphate, 7 cents per pound; lump lime, $1.70 per 100 pounds and two men and team at $8.00 per day, the cost per acre may be estimated as folllows:

Lime sulphur (5 gal. in 100)	$2.26
Calcium Caseinate (1 lb. in 100)	.56
Bordeaux (4-8-100)	1.36
Labor	2.00
Total cost per acre	$6.18

Table 3. Schedule and Dates of Applications.

	1922	1923	1924
1	April 18. Delayed dormant. Buds extended to ½ in. in length.	May 1. Delayed dormant. Buds extended to ½ in. in length.	May 6. Delayed dormant. Buds extended to ¾ in. in length and some leaves unfolding.
2	May 20. New shoots 6 to 12 in. long.		
3	June 2. A few blossoms open.	June 6. Blossoms just beginning to open. New shoots 18 to 20 in. long.	June 2. An occasional bud showing white. Shoot growth very slow; longest not over 6 in. long.
4	June 15. About 3 weeks before harvest.	June 28. About 2 weeks before harvest.	
5	Aug. 2. After harvest and old canes cut out.		

RESULTS FROM SPRAYING

The results from spraying may be measured in terms of (1) anthracnose control; (2) foliage injury, and (3) increase in fruit production. If anthracnose is controlled but the amount of fruit is not increased or the quality improved, spraying cannot be considered profitable.

Anthracnose Control. The seasons of 1922 and 1924 were favorable, while the summer of 1923 was unfavorable for the spread of anthracnose.

In 1922, the first infection occurred between May 20 and June 1. Ob-

servations made on June 1 indicated that all the materials used were effective in preventing infection on the portions of the shoots covered by the application of May 20. On sprayed plants, practically all the lesions were beyond this protected portion of the shoot or, in other words, on growth which developed after May 20. On unsprayed plants the lesions were usually distributed from the base of the shoot well out towards the tip.

Other observations were made at that time to determine how effective the various materials used in the delayed dormant application had been in preventing the spread of anthracnose from the old canes. This was determined by making counts of diseased and clean canes and observing how numerous the lesions were under each treatment.

The abundance of the lesions on the shoots in sprayed rows varied considerably under different treatments, as shown in Table 4. In Plot 3 (bordeaux for all applications) and Plot 4 (bordeaux plus calcium caseinate for all applications) lesions were usually rather numerous on shoots which were diseased. In Plot 2 (lime-sulphur for delayed dormant, bordeaux plus resin fish-oil soap for summer applications) the number was variable, but in general they were less numerous than in Plots 3 and 4. In Plot 1 (lime-sulphur plus calcium caseinate for all applications) the small num-

Table 4. Effectiveness of Spraying Materials in Protecting New Shoots

Treatment		Number of Shoots Examined	Percentage affected with anthracnose
Plot 1. Lime-sulphur plus calcium caseinate for all applications.	Sprayed Check	171 172	5 98
Plot 2. Lime-sulphur only for delayed dormant, bordeaux plus soap for summer applications.	Sprayed Check	158 102	34 97
Plot 3. Bordeaux for all applications.	Sprayed Check*	173 180	43 67
Plot 4. Bordeaux plus calcium caseinate for all applications.	Sprayed Check	126 100	61 96

*These rows were not given the delayed dormant application, but did receive the first and second summer applications, the first of which was put on previous to the first infection period.

ber of shoots which were affected had only a few lesions. On unsprayed plants in all the plots lesions were usually present in large numbers. Lime-sulphur plus calcium caseinate (Plot 1) was much more effective than any other mixture. Lime-sulphur alone (Plot 2) ranked second and bordeaux when used for the dormant spray was of least value (Plots 3 and 4). The effectiveness of the materials applied in the delayed dormant application may have been affected by the material used in the succeeding application which was also made before spore discharge occurred.

During June, anthracnose did not spread to any appreciable extent in any sprayed row but it did develop seriously on all unsprayed rows. In Sep-

tember the percentage of diseased shoots on sprayed rows in Plot 1 had increased from 5 to 13 while all the canes in the unsprayed rows were affected. Satisfactory counts were not obtained in the other plots as the summer applications of bordeaux obscured the lesions badly in many places. There was, however, a distinct difference between the plots receiving the delayed dormant application of lime-sulphur and those receiving bordeaux. The results indicate also that the later applications were of little importance in the control of anthracnose.

The result of the work done in 1923 were not conclusive in so far as anthracnose control was concerned because weather conditions were unfavorable for its spread. In all plots a small amount developed late in the season on the outer portion of the shoots so that when the canes were tied up and cut off in the spring of 1924, many of them showed some anthracnose just below where they were pruned.

The season of 1924 was marked by conditions very favorable for the development of anthracnose which reached serious proportions where it was not checked by spraying. The number of applications was reduced to two. Because of the great retardation of all plant growth in 1924, the one summer application was not made until June 2, and about seven weeks elapsed between that application and harvest. No anthracnose on new shoots was found June 2, but between that date and harvest it developed on nearly all unprotected new growth. New shoots in unsprayed rows were seriously affected. The lesions in many instances were so numerous that they covered almost all of the upper surface of the shoots. Control was very satisfactory on the new shoots where lime-sulphur plus calcium caseinate spreader was used for the delayed dormant application (Plots 1 and 2 as shown in Table 1). Plot 1, sprayed with lime-sulphur, and Plot 2, with bordeaux, for the summer application showed no difference in the control attained. Plot 3 was sprayed the same as Plot 2 except that calcium caseinate was not used in the lime-sulphur for the delayed dormant application. The control in Plot 2 was slightly better than in Plot 3, but the addition of calcium caseinate did not improve the effectiveness of the lime-sulphur as greatly as in 1922. The control in Plot 4 which was sprayed with bordeaux for all applications, was less satisfactory than that obtained where lime-sulphur was used for the delayed dormant applications.

The fruit-bearing pedicels on unsprayed vines were badly affected with anthracnose, many of them being almost entirely girdled by the diseased areas. The pedicels on the vines in all sprayed rows, regardless of the materials used, were practically free from anthracnose. The leaves and petioles (leaf stems) on unsprayed plants were badly affected wiht anthracnose and to a slight degree this was true on sprayed rows. Very few leaves, however, had developed at the time of the summer application.

The results of the trials in 1924 were essentially the same as those obtained in 1922. The comparative effectiveness of the materials may be stated as follows: Lime-sulphur is better than bordeaux for the delayed dormant application and its effectiveness for this application is increased by the addition of calcium caseinate. Lime-sulphur and bordeaux seem to be equally effective for summer applications for the direct protection of new growth.

Foliage Injury. Comparatively little foliage injury developed early in the season in 1922 but all treatments after harvest caused a moderate amount

of injury. The general condition of the foliage in rows which had received summer applications of bordeaux was better than in those where lime-sulphur was used during the summer. This difference was due, not so much to any definite injury by lime-sulphur as to an apparent effect of bordeaux in giving the leaves a dark green color.

In 1923, conditions were apparently much more favorable for the development of foliage injury. The first summer application of lime-sulphur plus calcium caseinate caused considerable injury; this was mostly around the edges and at the tips of the leaves where the lime-sulphur had gathered in rather excessive amounts. This accummulation of spray material was probably increased by the spreader used and the injury had developed at the time of the second summer application. No bordeaux injury was found at that time. After the second summer application, the lime-sulphur injury developed rapidly and during harvest it was present to a rather serious extent. A small amount of bordeaux injury was evident at this time and increased slightly after harvest but it never became as serious as the lime-sulphur injury. The bordeaux used for the summer applications in 1922 and 1923 was made according to the 6-8-100 formula. In 1924 the 4-8-100 formula was used, and no calcium caseinate was added with the lime-sulphur for the summer application.

No definite foliage injury developed under any treatment in 1924. One or more of three factors may have been responsible for the absence of injury; namely: (1) The reduced number of summer applications; (2) the reduced strength of the bordeaux and the elimination of calcium caseinate from the summer application of lime-sulphur, and (3) conditions which were unfavorable for the development of foliage injury. There was, however, a difference similar to that observed in 1922 in the condition of the foliage in bordeaux and lime-sulphur sprayed rows. This refers entirely to summer applications.

Fruit Production. Records of fruit production were obtained in 1924 from all rows in each plot. The rows where these records were obtained were 15½ rods in length. It will be recalled that each plot consisted of six rows and that the two middle rows were left unsprayed as checks. The production records, which are presented in Table 5, are stated as the average number of quarts per row for each plot, the averages being for four sprayed and two unsprayed rows. The greater distance (10 feet) between plots did not have any appreciable effect on the production of the outside rows of each plot as the individual row records show that the outside rows did not produce more fruit than the adjoining rows. The general vigor of the plants varied somewhat from plot to plot; these differences are probably quite accurately reflected by the variation in production of the check rows in each plot.

The data given in Table 5 show a definite and significant gain in production as a result of spraying. Treated rows show increases over their checks of from 39 to 59 per cent. The greater part of these increases was undoubtedly due to the control of anthracnose during 1924 and not to any cumulative or hold-over effects of spraying in 1923. The canes in all plots, both sprayed and unsprayed, were, as previously stated, relatively clean in the spring of 1924, because the weather conditions the previous year were so unfavorable for the development of anthracnose. However, there were present near the tips of many canes a few lesions which served

as excellent sources of infection during the rainy periods of 1924. The result was that the fruit-bearing pedicels and the foliage on unsprayed plants were badly diseased with a consequent reduction in yield. The observations of all who were in touch with the work during the picking season indicate that the differences in production were largely due to larger size of the berries on the sprayed rows rather than to an increased number.

Table 5. Fruit Production on Sprayed and Unsprayed Dewberries.

Plot	Treatment	Average Production per Row (Quarts) Aug. 1	Aug. 11	Aug. 18	Aug. 25	Total	Production per acre (16 qt. cases)	Increase (cases)
1	Unsprayed	32	35	17	3	87	123	
	Sprayed	56	42	24	3	125	177	54
2	Unsprayed	38	35	18	5	96	136	
	Sprayed	49	50	30	5	134	190	54
3	Unsprayed	30	42	18	4	94	133	
	Sprayed	58	60	29	3	150	212	79
4	Unsprayed	23	25	12	5	64	91	
	Sprayed	31	36	22	5	94	133	42

Average Production per acre for all Plots.

Sprayed	178 cases
Unsprayed	120 cases
Increase from spraying	58 cases

Rain fell at frequent intervals both before and during the picking season, consequently, the lack of water in the soil and excessive transpiration due to dry air were not limiting factors. There were large differences in production even with these favorable conditions of water supply. In a season with plentiful and frequent rains during the early part of the summer so that anthracnose could develop as seriously as in 1924, and with hot and dry weather during the harvest period, it is probable that unsprayed rows would suffer more severely.

DISCUSSION

Anthracnose on dewberries may, in many seasons, cause a significant reduction in fruit. Such losses probably will not occur every year as the development of anthracnose depends on the prevalence of favorable weather conditions. During the course of the experiments here reported, anthracnose developed seriously in two out of three seasons and this may probably be taken as a fair average of what may be expected over a period of years. It has been shown in these experiments that anthracnose has caused significant losses because of lowered production, or to express it another way, the control of anthracnose, by proper spraying has resulted in significant increases in production.

The increase in production was gained at a cost of $6.18 per acre for materials and labor. The actual increase in production was 58 cases per acre. In some seasons the increase might be small; in others it might even be much greater than in 1924. It is probably safe to assume that for a period of years the increase would amount to 25 to 50 cases per acre. With an average selling price of $1.80 to $1.85 per case the total gain would then be from $45.00 to $90.00. After subtracting from this the cost of materials and labor there is left an estimated net return from spraying of about

$40.00 to $85.00 per acre. The cost of crates and picking has not been deducted.

Failure to control anthracnose may, as first shown, lower fruit production. Further than this, it is probable that the effects of anthracnose are cumulative so that the vigor of the plants is gradually reduced each year with a consequent reduction in the amount of fruit produced until the planting may become unprofitable much sooner than if anthracnose were not present.

The development of this disease may be checked on new plantings by the practice of a simple sanitary measure when the plants are set. In this connection the following statement is contained in a recent report of anthracnose investigations* "Six to twelve inches of the old canes are left on black raspberry nursery stock by nurserymen to facilitate handling. The disease is often abundant on these old cane stubs, and is, therefore, disseminated to the new plantings. Before nursery stock is planted these old canes should be carefully removed. Young plants obtained from the vicinity of old plants in the spring should be removed to the new plantings before they are four to six inches high, since infection of the young plants usually occurs soon after they have attained this much growth." This practice should be equally valuable when setting dewberry plants. However, anthracnose is present on many old plantings and will usually develop in time on new plantings. Under such conditions it may be controlled by proper spraying.

Summary of Results of Spraying Experiments. The results of the experiments herein reported show that anthracnose may be effectively controlled by proper spraying. Two applications have given satisfactory results: (1) a delayed dormant application, made when the buds had expanded to one-half, or three-quarters of an inch in length, and (2) a summer application, applied about one week before the blooming period began.

For the delayed dormant application lime-sulphur has given consistently better results than bordeaux. The effectiveness of the lime-sulphur may be increased by the addition of calcium caseinate spreader.

For the summer application, both lime-sulphur and bordeaux have given satisfactory results in the control of anthracnose, but lime-sulphur is much more likely to cause definite foliage injury and even when direct injury had not occurred the foliage of bordeaux-sprayed plants was usually better as evidenced by a darker green color. This summer application, which is made about one week before the blooming period begins, is especially important because of the protection given to the recently developed pedicels, peduncles, and leaves on the fruit-bearing laterals, as their growth is well advanced at that time.

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*Anthracnose of Cane Fruits and Its Control on Black Raspberries in Wisconsin, Leon K. Jones. Res. Bul. 59, Wisconsin Agricultural Experiment Station. 1924.

CONCLUSIONS

The following schedule and materials are recommended for the control of anthracnose on dewberries in Michigan:

1. Delayed dormant application, when the buds are one-half to three-quarters of an inch long. The canes should be tied up to the trellises before this application is made. Use liquid lime-sulphur, 5 gallons in 100, plus 1 pound of calcium caseinate. To control scale insects the strength of the lime-sulphur should be increased to 12½ gallons in 100.

2. About one week before the blooming period, use bordeaux which should be of the strength here indicated

Copper sulphate, 4 pounds
Lump lime, 8 pounds
Water, 100 gallons,

If hydrated lime is used, the quantity should be increased to 12 pounds.

All new growth, shoots, foliage and fruit-bearing shoots, should be well sprayed.

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